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EVALUATION OF TEMPORARY DAY-NIGHT VISIBLE RAISED PAVEMENT MARKER ADEQUACY

FINAL REPORT

BY

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1035 PARKWAY AVENUE
TRENTON, NEW JERSEY 08625

IN COOPERATION WITH THE
FEDERAL HIGHWAY ADMINISTRATION

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16. Abstract

Compared to paint, day-night/wet-night visible raised pavement markers improve construction zone traffic performance significantly. However, there is a need to find temporary marker and adhesive systems that are easy to install, durable under construction zone traffic and easy to remove when no longer needed. After initial screening, six marker types were tested further for visibility and durability. The manufacturer's adhesives were used in this phase. It was found that an adequate day-night/wet-night visible temporary marker should meet the following visibility related requirements:

- A streamlined profile.
- A cube corner or multiple glass lens reflector.
- A balance between the reflector and casing area exposed to the driver on the face of the marker.

In the next phase, hot melt adhesives were investigated as an enhancement over the existing butyl with primer and high pressure system. Selected hot melts

1. were easy to use,
2. set hard in a few minutes,
3. required no surface preparation, primer or pressure,
4. proved as durable or more durable than the butyl system, and
5. permitted easy removal with shovels when no longer needed.

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SUMMARY AND CONCLUSIONS

Temporary raised pavement markers are needed to provide day and wet night lane delineation in construction zones. However, marker durability must be improved. In this study, visibility, durability and the use of hot melt adhesives are addressed.

Markers

During the experiment, it was noted that the ideal marker should incorporate certain features and avoid others.

While the plastic cube corner type reflectors proved adequate, they lost over half of their visibility after six months of wear. The multiple glass lens reflector was the only one that retained 1,000 feet of dry night visibility after six months.

Also, the more the marker casing and reflector facing the driver is vertical and non-streamlined, the less likely motorists will be able to see the marker in the day with the sun behind the visible face and the more likely the marker will come off the pavement from tire impacts. One marker had a face toward the driver that sloped 60° from the pavement. This caused the visible face to go into a shadow and lose visibility. The same marker also experienced the highest losses, no doubt from tire impacts on its non-streamlined surface.

The ideal marker should also avoid dedicating too much visible surface to the reflector since the reflector has low visibility in the day. The visible surface of one marker was mostly reflector and was the least visible marker in the day.

Therefore, an adequate day-night construction zone marker should have the following features:

1. A streamlined profile.
2. A cube corner or multiple glass lens reflector.
3. A balance between the reflector and casing area exposed to the driver.

The following systems met the criteria:

1. A hollow acrylic marker with a sealed prismatic air cell reflector (Amerace Corporation Stimsonite 66B).
2. The combination of a domed shaped polyester marker (Traffic Safety Supply Company Titan TM-40) for day visibility and the filled ABS shell marker with a cube corner reflex reflector (I.T.L. Industries, Inc. Ray-o-Lite or equivalent) for night visibility.

Both systems used butyl adhesives on asphalt and concrete primed surfaces, and both systems were removed without any noticeable damage to the pavement.

Adhesives

Hot melt adhesives were studied as an alternative to butyl. Butyl requires a primer which must be allowed to dry and high pressure to set. In practice, these steps may not be followed and the marker may not adhere to the pavement. There are also problems with cold temperatures, rough pavement and incompatibility with some markers. On the other hand, hot melts require no primer or high pressure, can conform to pavement irregularities and can be used in a wide range of temperatures.

The following hot melt adhesives are described in Table 9 and should be considered for temporary day-night lane delineation on asphalt and concrete pavements:

1. With ceramic markers (Ferro Corporation P-15), consider bitumin, epoxy thermoplastic, and thermoplastics for fabric and polyethylene, metal and olefin and metal and paper.
2. With acrylic markers (Amerace Corporation Stimsonite 66B) consider rubberized asphalt and general purpose thermoplastics.
3. With epoxy markers (I.T.L. Industries, Inc. Ray-O-Lite) consider epoxy thermoplastic and thermoplastics for general purposes, fabric

and polyethylene, metal and paper, metal and plastic, and ABS plastic and road surfaces.

4. With polyester markers (Traffic Safety Supply Co. Titan TM-40) consider bitumin, rubberized asphalt, and thermoplastics for metal and olefin.

No one adhesive worked with all the marker types. All of the hot melt adhesives that performed well had a low hot viscosity. To use hot melts, markers should be ordered without adhesives. The full potential of hot melts will be realized after large scale installations.

INTRODUCTION

Problem

Compared to paint, day-night/wet-night visible raised pavement markers improve construction zone traffic performance significantly. However, the only day-night/wet-night visible marker available until recently was the ceramic marker. Ceramic markers are designed for permanent installation with epoxy adhesives. In construction zones, a butyl adhesive is used to adhere the markers to the pavement to permit easy removal. However, the combination of heavy weaving traffic and butyl adhesives caused the markers to break up, especially on concrete pavements. When panel adhesives were tried, the results were much the same: the ceramics broke or came off.

Background

A recent report by Davis[1] showed that raised reflective ceramic markers as a paint replacement proved to be day visible and also provided night and wet pavement lane delineation superior to that provided by paint. The markers decreased lane changes and night lane encroachments. Unfortunately, 25 percent of the markers were lost or damaged within six days while under traffic. The markers were adhered to the pavement with butyl adhesives.

Likely, the losses were due to a combination of heavy, weaving traffic and the butyl adhesives. Another experiment in the same report showed that ceramic marker losses were two times higher on concrete than on asphalt pavements. Also, while a commonly used plastic marker (not day visible) experienced a 29 percent failure rate, the ceramic marker experienced a 79 percent failure rate.

Other reports related similar experiences with ceramic markers. Niessner[2] reported: "On one project nearly 80 percent of the ceramic markers placed with the butyl pads were missing or damaged in 4½ months. It was learned that the contractor used this detour to bring all of his heavy equipment onto and off of the construction site. This fact, combined with the narrow nine foot lanes on the detour, may, in part, explain the poor performance of the ceramic markers. The damage and loss record for this location seems to indicate that a butyl pad does not afford the ceramic markers with the support and adhesive properties it requires."

Lanz[3] reported on a permanent (non-construction) installation of ceramic markers. While the five to ten percent overall annual loss may seem relatively small, he noted that: "Many of these markers failed because of a poor bond. Traffic is detrimental to ceramic markers in curves and in areas with much lane crossing. Replacement of ceramic markers is necessary in several locations where up to fifty percent are missing in one-half mile stretches." The markers were installed with epoxy adhesives.

Objectives

The objectives of this experiment are twofold:

1. Find temporary day-night visible raised pavement markers that provide adequate visibility even under adverse environmental conditions, excluding snow, and endure for at least six months under various traffic loads on concrete and asphalt pavements.

2. Investigate hot melt adhesives that allow easy, durable and economical marker installations without compromising removability when the markers are no longer needed.

MARKERS

Procedure

First, 14 manufacturers located in technical catalogues were solicited for samples of day-night visible raised pavement markers (Table 1). Initially, accepted markers had to be easy to install and present no hazard to drivers. A night reflective marker was assumed to also be rainy night visible. From this criteria, six markers were selected for study of their features (Table 2 and Figures 1 through 6).

Next, the six selected marker types were installed with the adhesives supplied in a parking lot for about a month and exposed to weather and run over at random. They did not crack, turn or fall off, and they were removable with a shovel. Five marker types came with butyl adhesives and one came with a thermoplastic adhesive.

Then, the candidate marker types were tested for visibility while new. Yellow and white markers were studied on unopened sections of asphalt and concrete road. Thirty-three of each type of marker were installed at six foot intervals side by side as shown in Figures 7 and 8. Eight observers independently judged the visibility of the markers from a car with the sun behind, the sun in front and at night and recorded the measured distance on a questionnaire as to where they could detect each marker.

Following the visibility study, the markers were installed at six sites with various pavement and traffic characteristics described in Table 3 and Figures 9 through 14. In late May and early June, the six white marker types were randomly installed at six foot intervals between skip lines at each site in the

TABLE 1

RESULTS OF COMPANY SURVEY

	MANUFACTURER	MODEL	COMMENTS
1.	Amerace Corporation	Stimsonite 66B	Test further
2.	Baldwin Designs, Inc.		No response
3.	Borg-Warner Corp.		No response
4.	D. Swarovski and Co.	Swareflex 3557	Test further
5.	Ferro Corporation	Ceramic P-15	
6.	General Steel Industries, Inc.		None available
7.	I.T.L. Industries, Inc.	Ray-o-Lite	Test further
8.	Olympic Machines, Inc.	44C	Test further
9.	Prismo Universal Corp.	Prismo road stud	Drilling required
10.	Reflecting Road Studs, Ltd.	Catseye road studs	No response
11.	Reflexite Corp.		None available
12.	Traffic Safety Supply Co.	Dur-o-Line	No adhesive supp
13.	Traffic Safety Supply Co.	Titan TM-40	No reflector
14.	Universal	Flexiflector	Too late

TABLE 2

MARKER DESCRIPTION

COMPANY	MODEL	BODY TYPE	REFLECTOR TYPE
Ferro Corp.	P-15	Ceramic	Microscopic cube corner
Amerace Corp.	Stimsonite 66B	Hollow acrylic shell	Sealed prismatic air cell
I.T.L. Industries Inc.	Ray-o-Lite	Epoxy filled High Impact ABS	Cube corner
Traffic Safety Supply Co.	Titan TM-40	Polyester	None
D. Swarovski and Co.	Swareflex 3557	ABS shell	Multiple glass lenses
Olympic Machines, Inc.	44C	Polymer	Single glass lens

Figure 1. Ferro Corp. P - 15

Figure 2. Amerace Corp. Stimsonite 66 B

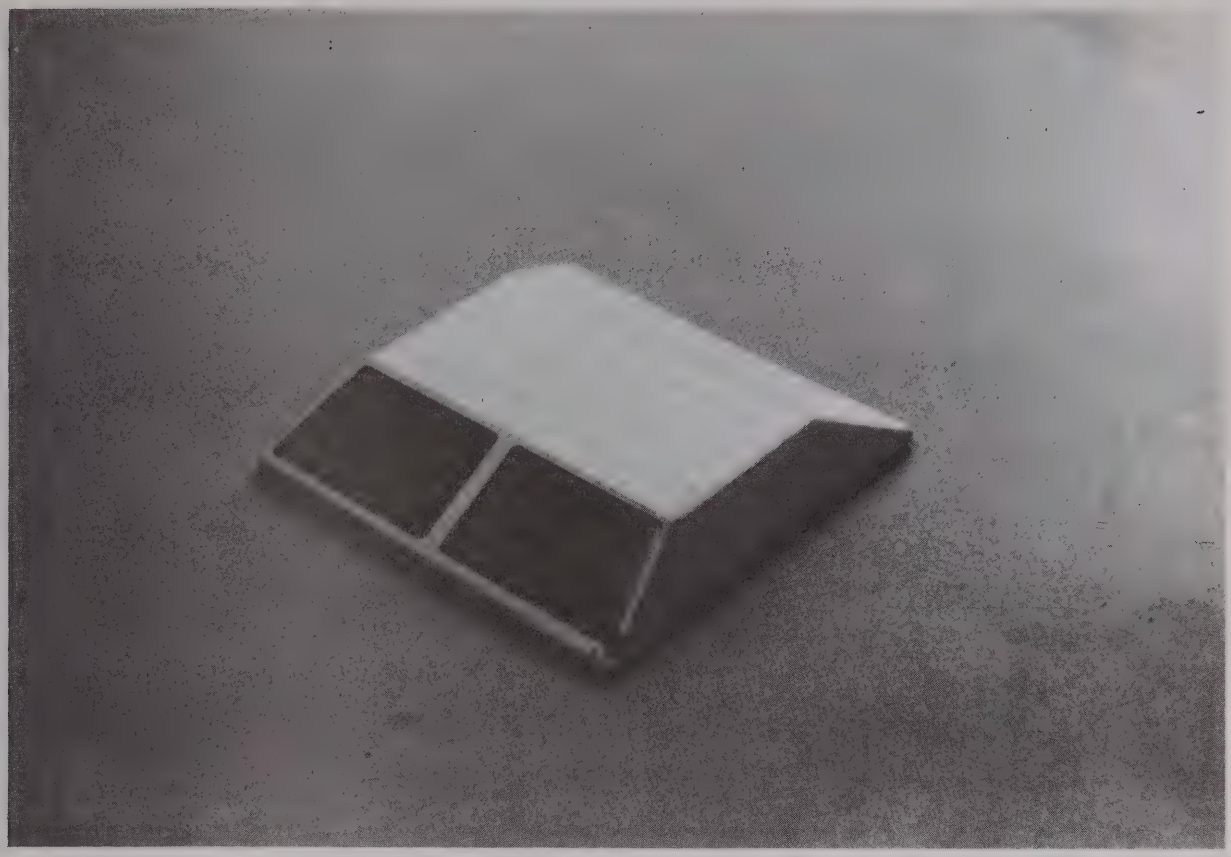

Figure 3 I.T.L. Industries, Inc.
Ray-O-Life

Figure 4. Traffic Safety Supply Co.
Titan TM-40

Figure 5. D. Swarovski and Co.
Swareflex 3557

Figure 6. Olympic Machines, Inc.
44C

Figure 7. Day Visibility Test
From 200 feet away

Figure 8. Night Visibility Test
From 200 feet away.

TABLE 3

SITE DESCRIPTION

SITE	Location	Pavement	Traffic Pattern	AADT (1000)	Marker Types	Test Sections	Total Markers
1	State Highway	Asphalt	Weave	33	6	21	126
2	Interstate	Concrete	Weave	40	6	8	48
3	Interstate	Asphalt	Exit	33	6	14	84
4	Interstate	Concrete	Exit	27	6	5	30
5	Interstate	Asphalt	Split	21	6	15	90
6	Interstate	Concrete	Split	25	6	15	90

NOTE: AADT is the volume of traffic entering the section where the markers are installed.
Markers were placed at 6 foot intervals between skip lines in the gore area
Total represents white markers only.

Figure 9. Site 1

Figure 10. Site 2

Figure 11. Site 3

Figure 12. Site 4

Figure 13. Site 5

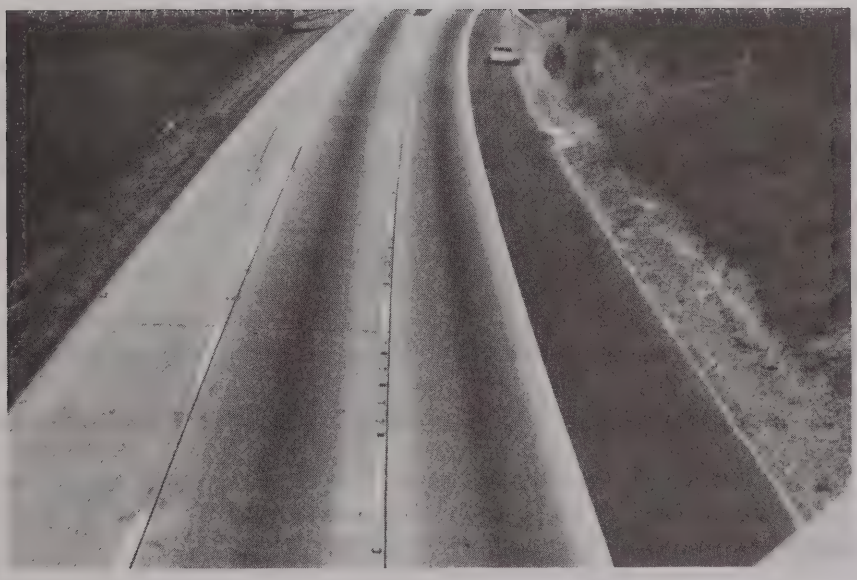

Figure 14. Site 6

gore area. For six months, the markers were monitored at twelve periodic intervals for cracks, losses, turns, slips and dirt. The yellow markers were randomly installed next to the left edgeline and were studied for effects from the environment.

Following the six-month durability study, the markers were totally removed with snowplows without noticeable damage to the pavement and the worn markers were judged for visibility in the same manner as when new.

Results

Visibility When New - The results of the initial visibility studies are shown in Tables 4 and 5. The Ferro Corporation's P-15 ceramic marker was the control used in the experiment since it was specified for use by the New Jersey Department of Transportation. The candidate markers were to equal or surpass the visibility of the ceramic. Significant changes were detected with the paired t-test at the 95 percent level of confidence.

The Ray-o-Lite on concrete with partial sun, the Swareflex on concrete with partial sun behind the face and the Olympic Machine at night were not as visible as the ceramic. With yellow markers, the Ray-o-Lite on concrete with partial sun in the marker face and the Swareflex on asphalt with overcast sun behind the marker face were not as visible as the ceramic marker. Also, note how the Stimsonite and the Titan on concrete with partial sun behind the face surpassed the ceramic visibility.

Durability - The results of the durability tests are summarized in Table 6. Only the white markers were studied since they experienced hits from weaving traffic while the yellow edge markers did not. The three asphalt and three concrete site data have been combined since they were matched pairs.

The Swareflex on asphalt and concrete and the Olympic Machines on concrete proved less durable than the ceramic on butyl.

TABLE 4

VISIBILITY OF WHITE MARKERS WHEN NEW (in feet)

MARKER	CONCRETE PAVEMENT		ASPHALT PAVEMENT		NIGHT
	Partial Sun In Face	Partial Sun Behind Face	Overcast Sun In Face	Overcast Sun Behind Face	
Ferro P-15 Ceramic Control Marker	1125	1125	1025	1000	1100
Stimsonite 66B	1150	1125	1200	975	1025
Ray-o-Lite	473*	490*	1000	800	1000
Titan TM-40	1150	1125	1200	1000	non-reflective
Swareflex 3557	1125	624*	1050	975	1100
Olympic Machines 44C	1143	1125	1200	1000	457*

*Significant change from Ferro P-15 ceramic control marker at the 95 percent level of confidence.

TABLE 5

VISIBILITY OF YELLOW MARKERS WHEN NEW (in feet)

MARKER	CONCRETE PAVEMENT		ASPHALT PAVEMENT		NIGHT
	Partial Sun In Face	Partial Sun Behind Face	Overcast Sun In Face	Overcast Sun Behind Face	
Ferro P-15 Ceramic Control Marker	1050	748	1025	875	1013
Stimsonite 66B	1100	1050*	1075	875	1000
Ray-o-Lite	476*	627	995	856	1063
Titan TM-40	1075	1075*	1100	925	non-reflective
Swareflex 3557	1050	730	1025	617*	1013
Olympic Machines 44C	N/A	N/A	N/A	N/A	N/A

*Significant change from Ferro P-15 ceramic control marker at the 95 percent level of confidence.

TABLE 6

DURABILITY AFTER SIX MONTHS

	ASPHALT			CONCRETE		
MARKER	Number Installed	Number Left	Percent Left	Number Installed	Number Left	Perc Left
Ferro P-15 (Control)	51	29	57	28	15	54
Stimsonite 66B	50	47	94	28	23	82
Ray-o-Lite	50	43	86	28	24	86
Titan TM-40	50	50	100	28	28	100
Swareflex 3557	37	14	38	28	12	43
Olympic Machines 44C	49	43	88	28	12	43

Visibility After Six Months of Wear - Since the Stimsonite marker came off the pavement in fragments and only nine white ones could be fitted together, nine of each of the six markers were used in the final visibility survey. The other markers came off the pavement intact, and there was no noticeable damage to the pavement. The visibility was measured using the same procedure followed for new marker visibility and the results are in Tables 7 and 8.

The day visibility of the Ray-O-Lite and Swareflex and the night visibility of the Olympic Machines markers was significantly below the ceramic visibility. Note however, the outstanding night visibility results for the Swareflex marker. The fragmented nature of the Stimsonite affected its visibility. As proof, note the exceptional visibility of the yellow Stimsonite which was less damaged.

As far as the yellow markers are concerned, the Ray-O-Lite and the Swareflex again experienced daytime visibility problems and the Olympic Machines was not visible enough at night. Note the outstanding day visibility of the Stimsonite and the Olympic Machines. No doubt the fragmented nature of the Stimsonite affected its night visibility.

HOT MELT ADHESIVES

Procedures

Hot melt features were studied through a market survey, a test track experiment and field studies.

First, 30 hot melt adhesives listed alphabetically in Table 9 were obtained from manufacturers listed in a catalogue for New Jersey, Pennsylvania and New York. As an experiment control, butyl with primer and high pressure was included in the evaluation. A new soft butyl that did not require primer or high pressure was also tried.

Next, all 30 samples were applied to four adequate marker types on a test track. The markers were: the Stimsonite 66B, the Ray-O-Lite, the Titan TM-40

TABLE 7

VISIBILITY OF WHITE MARKERS AFTER SIX MONTHS OF WEAR (in feet)

MARKER	CONCRETE PAVEMENT		ASPHALT PAVEMENT		NIGHT
	Partial Sun In Face	Partial Sun Behind Face	Overcast Sun In Face	Overcast Sun Behind Face	
Ferro P-15 Ceramic Control Marker	1048	583	1042	1048	419
Stimsonite 66B	1048	196*	1048	1030	271*
Ray-o-Lite	656*	88*	1042	1042	385
Titan TM-40	1048	520	1048	1042	non-reflective
Swareflex 3557	1048	129*	1042	1042	1041*
Olympic Machines 44C	1142	450	1048	1042	246*

*Significant change from Ferro P-15 ceramic control marker at the 95 percent level of confidence.

NOTE: Since the Stimsonites came off the pavement in pieces, their visibility results were lower than they would have been had they come off intact like the other markers.

TABLE 8

VISIBILITY OF YELLOW MARKERS AFTER SIX MONTHS OF WEAR (in feet)

MARKER	CONCRETE PAVEMENT		ASPHALT PAVEMENT		NIGHT
	Partial Sun In Face	Partial Sun Behind Face	Overcast Sun In Face	Overcast Sun Behind Face	
Ferro P-15 Ceramic Control Marker	978	290	1019	1041	1022
Stimsonite 66B	1030	452*	1048	1048	826*
Ray-o-Lite	675*	77*	1027	1034	1048
Titan TM-40	944	261	1041	1041	non-reflective
Swareflex 3557	935	60*	1019	1034	1027
Olympic Machines 44C	957	442*	1041	1048	290*

*Significant change from Ferro P-15 ceramic control marker at the 95 percent level of confidence.

NOTE: Since the Stimsonites came off the pavement in pieces, their visibility results were lower than they would hae been had they come off intact like the other markers.

TABLE 9

HOT MELT ADHESIVE DESCRIPTION

COMPANY	PRODUCT	BASE	INDUSTRIAL USE
Allied Adhesive Corp.	CH - 67	Thermoplastic	general purpose
	RC - 56	Thermoplastic	catch mice
Amerace Corp.	Bitumin (1)	Bitumin	Acrylic and Road
American Coating and Chemical Company, Inc.	Hot Melt	Thermoplastic	Metal and Paper
	Hot Melt 2	Thermoplastic	Fabric and Polyethylene
Atochem Polymers, Inc.	RDS - 4	Thermoplastic	Textiles
	H 585	Thermoplastic	Textiles
	M 548	Thermoplastic	Textiles
BF Goodrich Co.	PL 800	Thermoplastic	Paper, Fabric and rubber
	PL 824	Thermoplastic	Wood and Plastic
	PL 826	Thermoplastic	Metal and Olefin
	PL 904	Thermoplastic	Auto parts
Bond Narrow Fabric Co., Inc.	16014	Thermoplastic	General Purpose
Borden Chemical	HA 6600	Thermoplastic	Packaging
	HA 6650	Thermoplastic	Packaging
	HC 6164	Thermoplastic	Metal and Plastic
D. Swarovski and Co.	SK 7678 (2)	Thermoplastic	ABS Plastic and Road
Findley Adhesives, Inc.	319-334	Thermoplastic	Cartons
Fuller, H.B. Co.	HM - 1628C	Thermoplastic	Metal and Plastic
	HM - 3315	Thermoplastic	Metal and Plastic
	HM - 8340	Thermoplastic	General Purpose
National Adhesives	34-3402	Thermoplastic	PVC and Wood
	88-7051	Thermoplastic	Weatherstriping
Pierce and Stevens Chemical Corp.	A 4607	Thermoplastic	Packaging
	A 4635J	Thermoplastic	Art and Foam
	A 4674	Thermoplastic	Packaging
	A 4953	Thermoplastic	Packaging
Trumbull Asphalt Co.	Joint Filler	Rubberized Asphalt	Joint Filler
West Chester Co.	Epoflex A	Epoxy Thermoplastic	Glass Beads and Road
	Epoflex B	Epoxy Thermoplastic	Glass Beads and Road

** Notes **

(1) provided for Stimsonite 66B marker

(2) provided for Swareflex 3557 marker

and the ceramic. The Stimsonite, Ray-O-Lite and Titan markers proved adequate in the previous phase of this project, and the ceramic marker was included to see if it would prove more durable with hot melts. The test track was an unopened section of asphalt pavement, and butyl was used as a control. To qualify for further evaluation, the adhesive was to melt in a can and readily pour onto the pavement and set within a few minutes. Then the marker-adhesive combinations were to endure passes of a loaded dump truck, a rubber tipped snowplow blade and a skidding tire (Figures 15 and 16). The markers were removed with a shovel.

In May, 1986, the ceramic P-15, the Stimsonite 66B, the Ray-O-Lite and the Titan TM-40 markers were installed at two sites with 23 different adhesives that passed the test track plus two butyl adhesives (Figure 17). Two hundred seventy-six markers were installed at random between the 14 skip lines preceding an interstate highway exit to a state highway. The pavement was asphalt and the AADT was 35,400 in the direction the markers were installed. Another 288 markers were installed at random between 15 skip lines preceding the split of an interstate to another interstate highway. The pavement was concrete and the AADT was 24,800 in the direction the markers were installed. The adhesives were put into cans and heated in a portable propane fueled oven. The control was the butyl with primer set with high pressure. An acceptable hot melt adhesive would equal or surpass the durability of the butyl-primer-pressure method. The exception would be with the ceramic. Since the ceramic on butyl was not a durable system, the ceramic on hot melt would have to experience no losses to qualify.

Results

Test Track - Only seven of the 30 hot melts failed the test track experiment. Two were too thick to pour easily, four were too easy to remove and one was too difficult to remove (see Table 10).

Figure 15. Rubber Tipped Snowplow Blade Experiment

Figure 16. Skidding Tire Experiment

Figure 17. Field Evaluation of Adhesive Durability

TABLE 10

TEST TRACK RESULTS FOR MARKER HOT MELT ADHESIVES

COMPANY	PRODUCT	HOT POUR	EASE OF REMOVAL				COMMENTS
			CERAMIC	ACRYLIC	EPOXY	POLYESTER	
Various	Butyl	Na	Medium	Hard	Medium	Hard	Control
Ferro Corp.	Butyl	Na	Medium	Hard	Medium	Hard	No Primer
Allied Adhesive Corp.	CH - 67	Thin	Medium	Medium	Medium	Medium	Test Further
	RC - 56	Thin	By hand	By Hand	By Hand	By Hand	Poor Bond
Amerace Corp.	Bitumin (1)	Thin	Medium	Medium	Medium	Medium	Test Further
American Coating and Chemical Company, Inc.	Hot Melt	Thin	Medium	Medium	Medium	Hard	Test Further
	Hot Melt 2	Thin	Easy	Easy	Easy	Plowed	Test Further
Atochem Polymers, Inc.	RDS - 4	Thin	Easy	Easy	Easy	Easy	Test Further
	H 585	Thin	Easy	Medium	Easy	Medium	Test Further
	M 548	Thin	Easy	Easy	Hard	Easy	Test Further
BF Goodrich Co.	PL 800	Medium	Easy	By Hand	Easy	Easy	Test Further
	PL 824	Medium	By hand	By Hand	Easy	Plowed	Poor Bond
	PL 826	Thin	Medium	Hard	Medium	Medium	Test Further
	PL 904	Thick	Hard	Hard	Easy	Hard	Too Thick
Bond Narrow Fabric Co., Inc.	16014	Thin	Easy	Easy	Easy	Easy	Test Further
Borden Chemical	HA 6600	Thin	Medium	Easy	Easy	Easy	Test Further
	HA 6650	Thin	Medium	Easy	Easy	Medium	Test Further
	HC 6164	Medium	Medium	Easy	Medium	Easy	Test Further
D. Swarovski and Co.	Sk 7678 (2)	Thin	Easy	Easy	Easy	Easy	Test Further
Findley Adhesives, Inc.	319-334	Thin	Plowed	Plowed	Plowed	By Hand	Poor Bond
Fuller, H.B. Co.	HM - 1628C	Thin	Easy	Easy	Easy	Easy	Test Further
	HM - 3315	Thin	Easy	Easy	Medium	Easy	Test Further
	HM - 8340	Thin	Medium	Medium	Medium	Medium	Test Further
National Adhesives	34-3402	Thin	Easy	Easy	Easy	By Hand	Test Further
	88-7051	Thick	Easy	Easy	Easy	Easy	Too Thick
Pierce and Stevens Chemical Corp.	A 4607	Thin	Medium	Hard	Easy	Hard	Test Further
	A 4635J	Thin	Very hard	Very Hard	Very Hard	Hard	Bond Too Strong
	A 4674	Thin	Plowed	Plowed	Easy	By Hand	Poor Bond
	A 4953	Thin	Easy	Hard	Medium	Very Hard	Test Further
Trumbull Asphalt Co.	Joint Filler	Thin	Easy	Medium	Medium	Medium	Test Further
West Chester Co.	Epoflex A	Thin	Easy	Easy	Easy	Easy	Test Further
	Epoflex B	Thin	Easy	Easy	Easy	Easy	Test Further

** Notes **

(1) provided for Stimsonite 66B marker

(2) provided for Swareflex 3357 marker

Field Evaluation - Tables 11 through 14 present the results of the field tests by marker type. Some adhesives were so similar that their results were combined. The adhesives were ranked according to their weighted averages in the last column. No one hot melt worked with all four marker types. All of the hot melt adhesives that proved adequate had a low hot viscosity. None of the packaging or textile adhesives worked with any of the markers. A summary of the field results is found in Table 15. For each marker type there are several hot melts that equal or surpass the durability of the butyl pad on primer without compromising removability. In fact, some hot melts permit even easier removal.

TABLE 11 DURABILITY OF CERAMIC MARKER-HOT MELT ADHESIVE SYSTEMS AFTER SIX MONTHS OF WEAR

Industry Use	Base	Hot Pour	Removal	Asphalt		Concrete		Weighted Average
				Number Put Down	Percent Left	Number Put Down	Percent Left	
marker,road	butyl(CONTROL)	na	medium	4	75	4	75	75
ceramic,road	butyl(no primer)	na	medium	4	0	1	100	20
metal,paper	thermoplastic	thin	medium	4	100	2	100	100
fabric,polyethylene	thermoplastic	thin	easy	4	100	3	100	100
metal,olefin	thermoplastic	thin	medium	4	100	4	100	100
acrylic, road	bitumin	thin	medium	4	100	4	100	100
glass beads,road	epoxy thrmplstc.	thin	easy	8	100	3	100	100
ABS plastic,road	thermoplastic	thin	easy	4	50	4	100	75
joint filler	rubberized asphlt	thin	easy	4	100	2	0	67
packaging	thermoplastic	thin	medium	16	50	9	78	60
general purpose	thermoplastic	thin	medium	8	38	10	60	50
paper,fabric,rubber	thermoplastic	medium	easy	1	0	3	67	50
metal,plastic	thermoplastic	thin	easy	8	50	8	38	44
metal,plastic	thermoplastic	medium	medium	4	0	1	100	20
pvc,wood	thermoplastic	thin	easy	4	0	2	50	17
textile	thermoplastic	thin	easy	12	0	7	43	16

TABLE 12 DURABILITY OF EPOXY MARKER-HOT MELT ADHESIVE SYSTEMS AFTER SIX MONTHS OF WEAR

Industrial Use	Base	Hot Pour	Removal	Asphalt		Concrete		Weighted Average
				Number Put Down	Percent Left	Number Put Down	Percent Left	
marker,road	butyl(CONTROL)	na	medium	4	25	4	75	5
ceramic,road	butyl(no primer)	na	medium	1	100	4	75	8
metal,olefin	thermoplastic	thin	medium	4	75	4	100	8
acrylic, road	bitumin	thin	medium	4	100	4	75	8
metal, plastic	thermoplastic	thin	easy	8	75	8	100	9
glass beads,road	epoxy thrmplstc.	thin	easy	8	75	3	100	8
general purpose	thermoplastic	thin	medium	8	63	10	90	7
ABS plastic, road	thermoplastic	thin	easy	4	25	4	100	6
fabric,polyethylene	thermoplastic	thin	easy	4	50	3	67	5
metal,plastic	thermoplastic	thin	medium	4	25	2	100	5
packaging	thermoplastic	thin	easy	16	31	9	56	4
joint filler	rubberized asphlt	thin	medium	4	25	2	50	3
metal,plastic	thermoplastic	medium	medium	4	0	1	100	2
textile	thermoplastic	thin	medium	12	17	7	0	1
pvc,wood	thermoplastic	thin	easy	4	0	2	0	0
paper,fabric,rubber	thermoplastic	medium	easy	1	0	3	0	0

TABLE 13 DURABILITY OF ACRYLIC MARKER-HOT MELT ADHESIVE SYSTEMS AFTER SIX MONTHS OF WEAR

Industrial Use	Base	Hot Pour	Removal	Asphalt		Concrete		Weighted Average
				Number Put Down	Percent Left	Number Put Down	Percent Left	
marker,road	butyl(CONTROL)	na	hard	4	0	4	100	50
ceramic,road	butyl(no primer)	na	hard	1	0	4	100	80
general purpose	thermoplastic	thin	medium	8	63	10	50	56
joint filler	rubberized asphlt	thin	medium	4	25	2	100	50
glass beads,road	epoxy thrmplstc	thin	easy	4	50	3	33	45
ABS plastic,road	thermoplastic	thin	easy	4	25	4	50	38
metal,plastic	thermoplastic	thin	easy	8	50	8	13	31
metal,olefin	thermoplastic	thin	hard	4	0	4	50	25
acrylic,road	bitumin	thin	medium	4	0	4	50	25
packaging	thermoplastic	thin	hard	16	19	9	22	20
metal,plastic	thermoplastic	medium	easy	4	0	1	100	20
metal,paper	thermoplastic	thin	medium	4	0	2	50	17
textiles	thermoplastic	thin	easy	12	8	7	0	5
fabric,polyethylene	thermoplastic	thin	easy	4	0	3	0	0
pvc,wood	thermoplastic	thin	easy	4	0	2	0	0
paper,fabric,rubber	thermoplastic	medium	hand	1	0	3	0	0

Table 14 DURABILITY OF POLYESTER MARKER-HOT MELT ADHESIVE SYSTEMS AFTER SIX MONTHS OF WEAR

Industrial Use	Base	Hot Pour	Ease of Removal	Asphalt		Concrete		Weighted Average
				Number Put Down	Percent Left	Number Put Down	Percent Left	
marker,road	butyl(CONTROL)	na	hard	4	100	4	100	10
ceramic,road	butyl(no primer)	na	hard	1	100	4	100	10
metal,paper	thermoplastic	thin	hard	4	100	2	100	10
metal,olefin	thermoplastic	thin	medium	4	100	4	100	10
joint filler	rubberized asphlt	thin	medium	4	100	2	100	10
acrylic,road	bitumin	thin	medium	4	100	4	100	10
metal,plastic	thermoplastic	thin	easy	8	88	8	100	9
packaging	thermoplastic	thin	hard	16	94	9	89	9
glass beads,road	epoxy thrmplstc	thin	easy	8	88	3	100	9
general purpose	thermoplastic	thin	medium	8	88	10	90	8
ABS plastic,road	thermoplastic	thin	easy	4	75	4	100	8
fabric,polyethylene	thermoplastic	thin	plowed	4	100	3	67	8
metal,plastic	thermoplastic	medium	easy	4	75	1	100	8
pvc,wood	thermoplastic	thin	by hand	4	50	2	0	3
paper,fabric,rubber	thermoplastic	medium	easy	1	0	3	33	2
textile	thermoplastic	thin	easy	12	25	7	14	2

TABLE 15

HOT MELT ADEQUACY BY MARKER TYPE

ADHESIVE	DURABILITY				EASE OF REMOVAL			
	Ceramic Marker	Acrylic Marker	Epoxy Marker	Polyester Marker	Ceramic Marker	Acrylic Marker	Epoxy Marker	Polyester Marker
Butyl	Control	Control	Control	Control	Control	Control	Control	Control
Bitumin	+	-	+	=	=	+	=	+
Epoxy Thermoplastic	+	-	+	-	+	+	+	+
Rubberized Asphalt	-	+	-	=	+	+	=	+
Thermoplastics for:								
ABS Plastic & Road	-	-	+	-	+	+	+	+
Fabric & Polyethylene	+	-	+	-	+	+	+	+
General Purposes	-	+	+	-	=	+	=	+
Metal & Olefin	+	-	+	=	=	=	=	+
Metal & Paper	+	-	+	=	=	+	=	=
Metal & Plastic	-	-	+	-	+	+	+	+

Note: + means more durable and easier to remove than butyl
= means as durable and removal as butyl
- means not as durable and more difficult to remove than butyl

All listed adhesives had a low hot viscosity

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